Electron Cloud at RHIC

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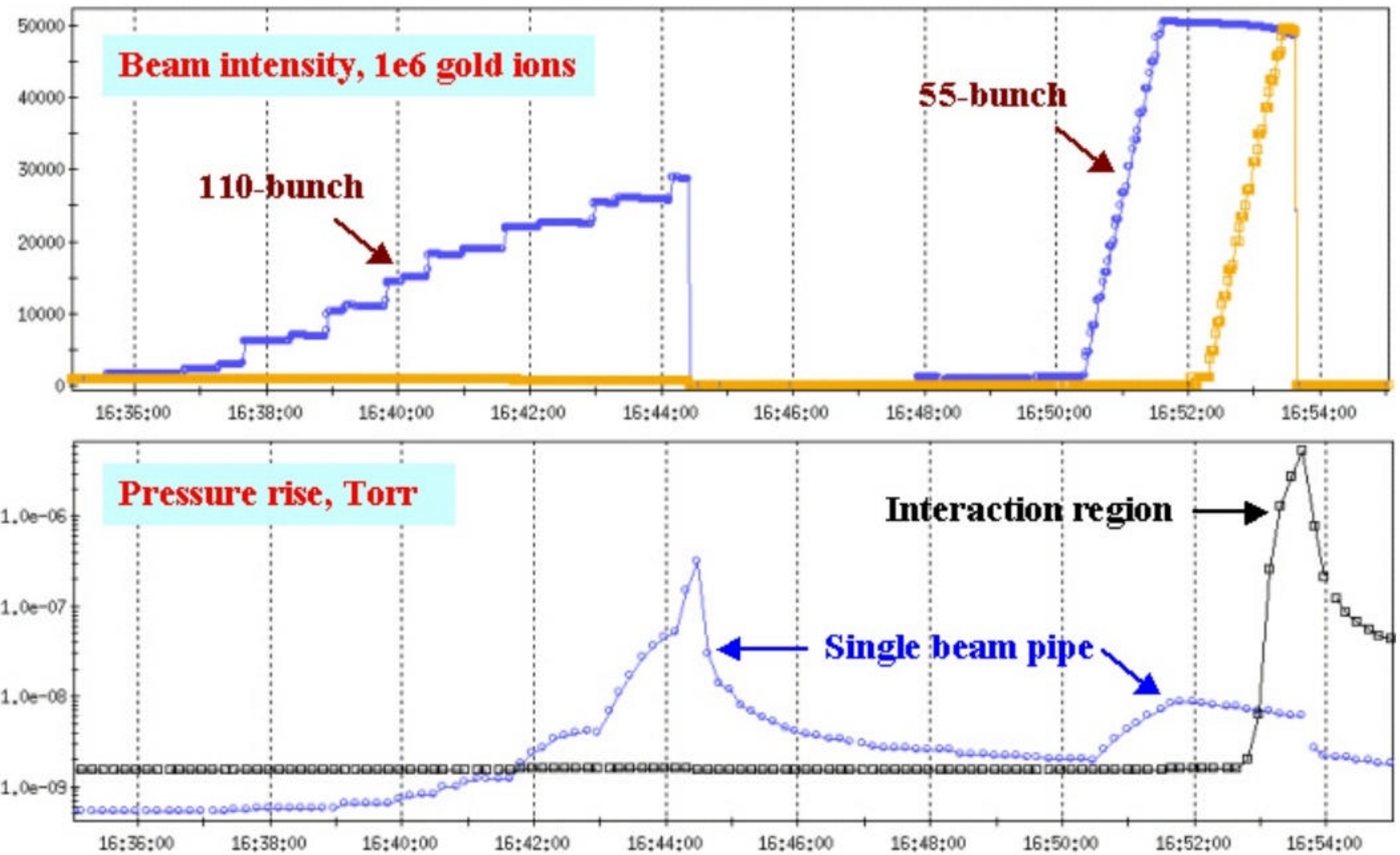
1. Introduction:
RHIC/LHC electron cloud main parameters

Beam Parameters Table: (RHIC and LHC)

	RHIC (FY2004)	*LHC*
Number of bunches	110	72/batch (Total: 2808)
Bunch Intensity	10^9 Au pb	10^11 ppb
Bunch Spacing	108 ns	25 ns
Bunch Length	5 ns (flattop)	0.25ns (flattop)
Energy	100/250 GeV	7 TeV
Circumference	3.8km	27km
Chamber surface	St. St./ NEG	Cu / NEG
SEY	2.1/ 1.3	2.1 / 1.3
Chamber Geometry	round/R=6cm/R=3.5cm	BS / a=18mm; b=22mm

2. Observations during FY2003



RHIC 2001:

-P rise with

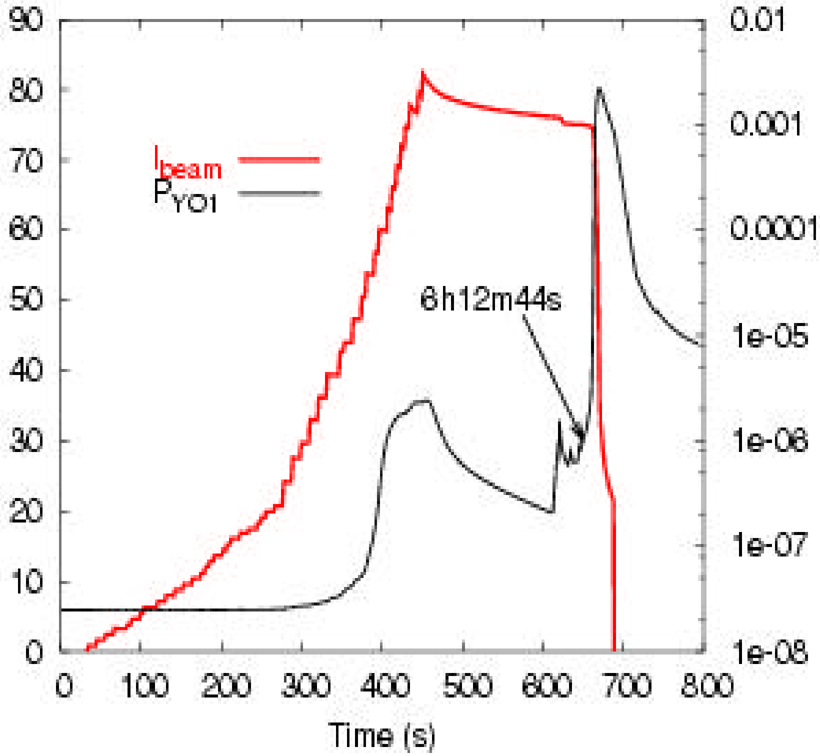
intense ion beams (A

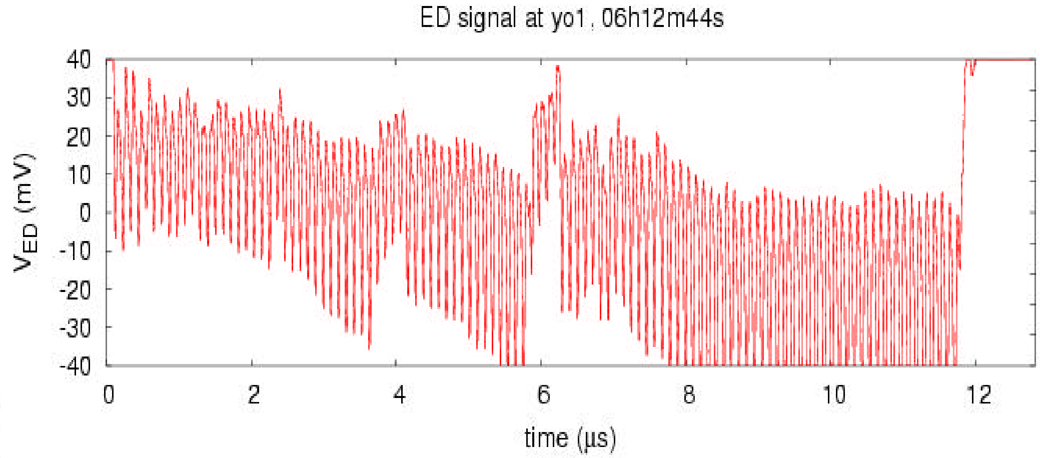
Courtesy of S.Y. Zhang

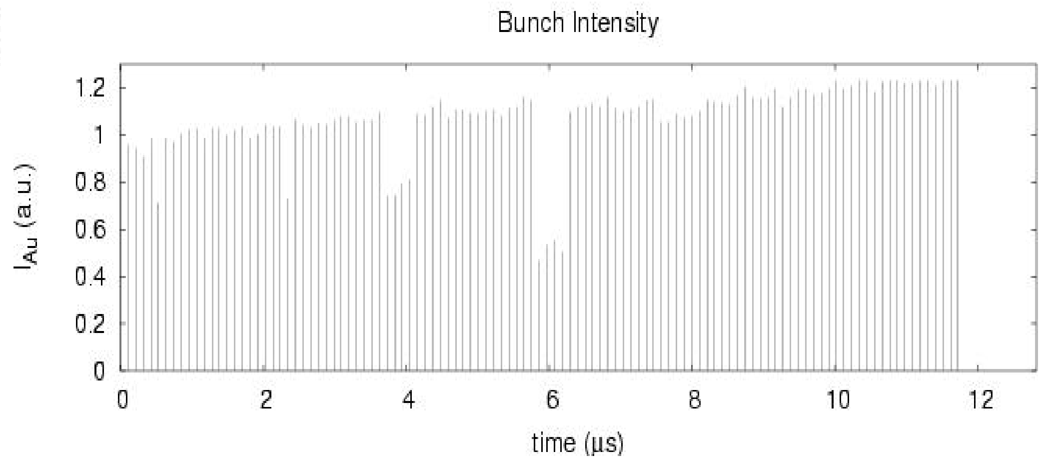
?During 2002 shutdown, up to 16 ED were installed at RHIC for EC diagnostics.

?That allowed to record EC for Au, d, and p: see next slides...

2.1. EC for *Au* during FY2003







?Highest N for Au achieved in 2003: $8 \cdot 10^8$ Au-pb

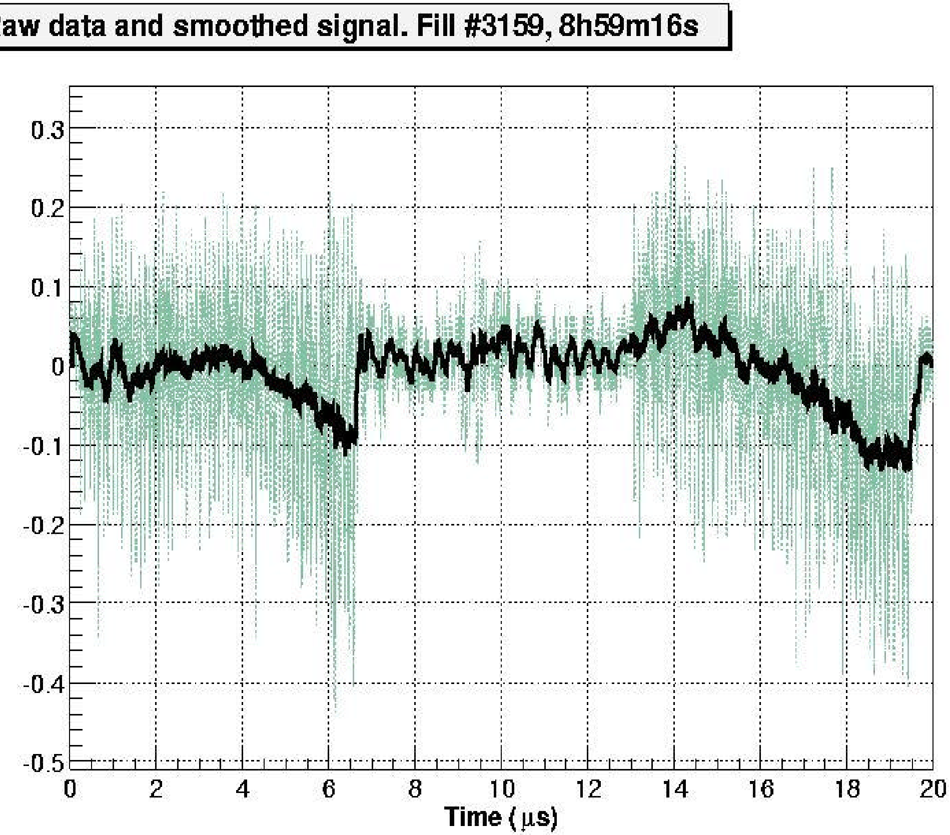
?Experimental threshold: $\sim 7 \cdot 10^8$ Au-pb

Fill #3107: EC produced high P rise right after transition started -->beam lost

2.2. EC for *d* and *p* during FY2003

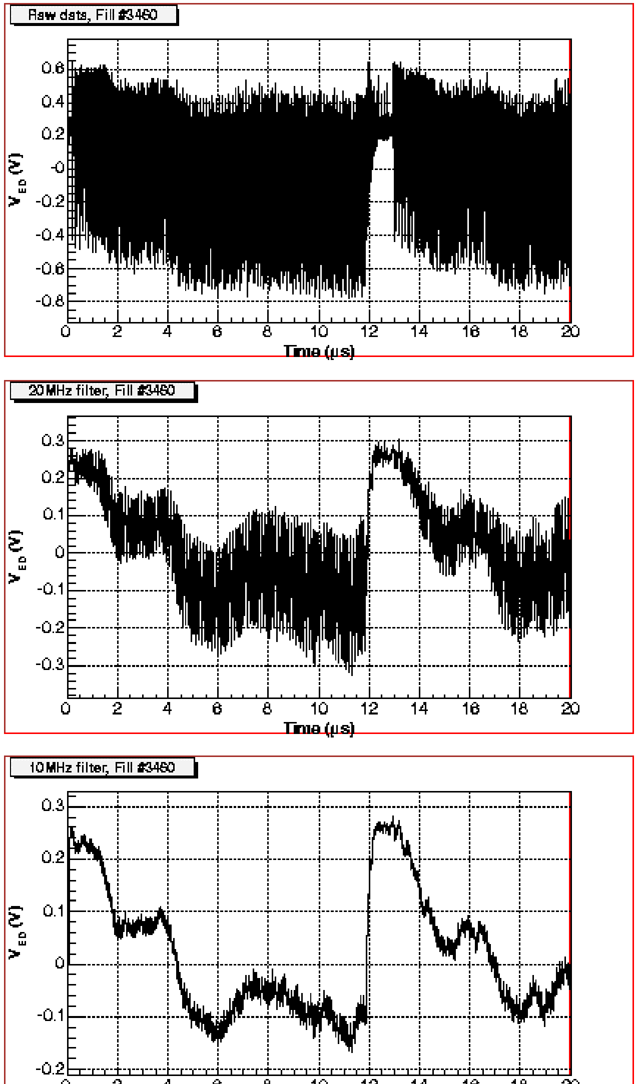
...and the importance of smoothing signals using the RHIC ED...

?*For d*



?*N=8.5•10^10 d-pb*

?*For p*



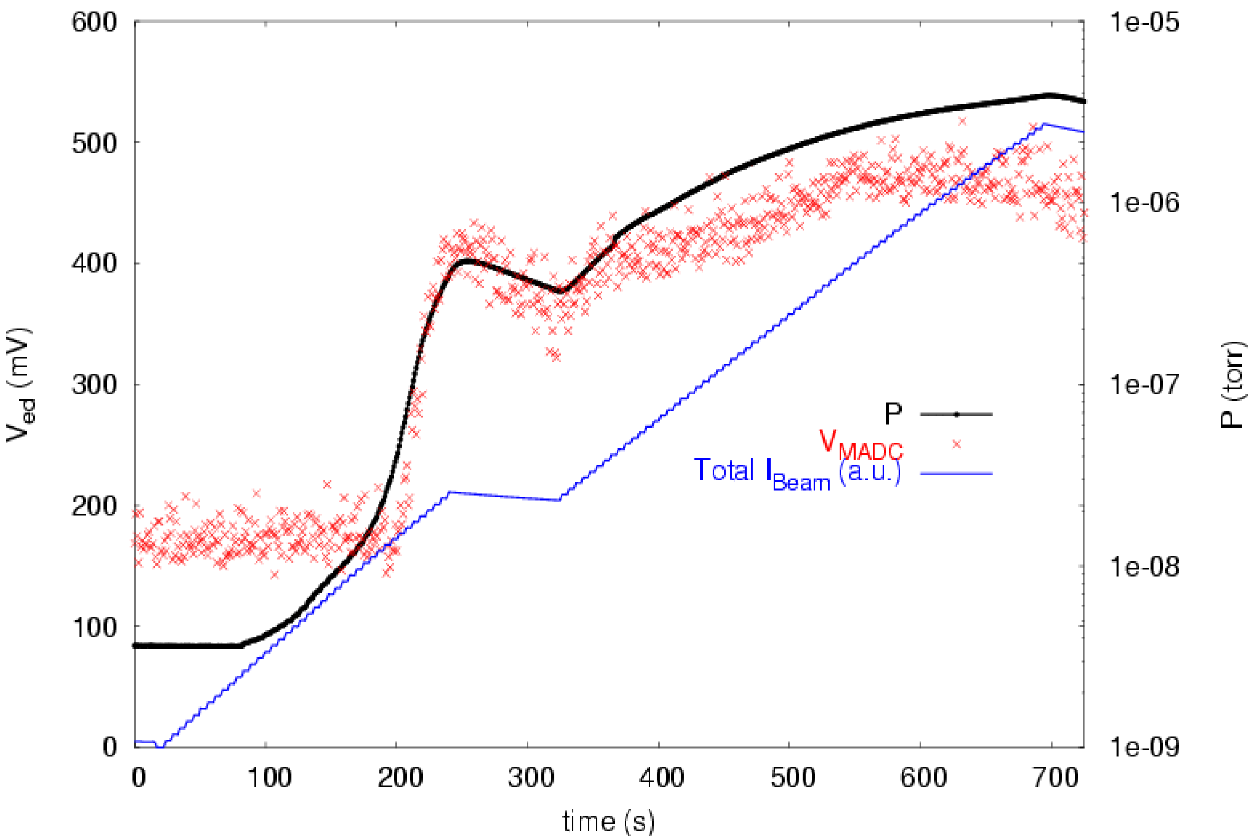
Raw data

20 MHz

10 MHz

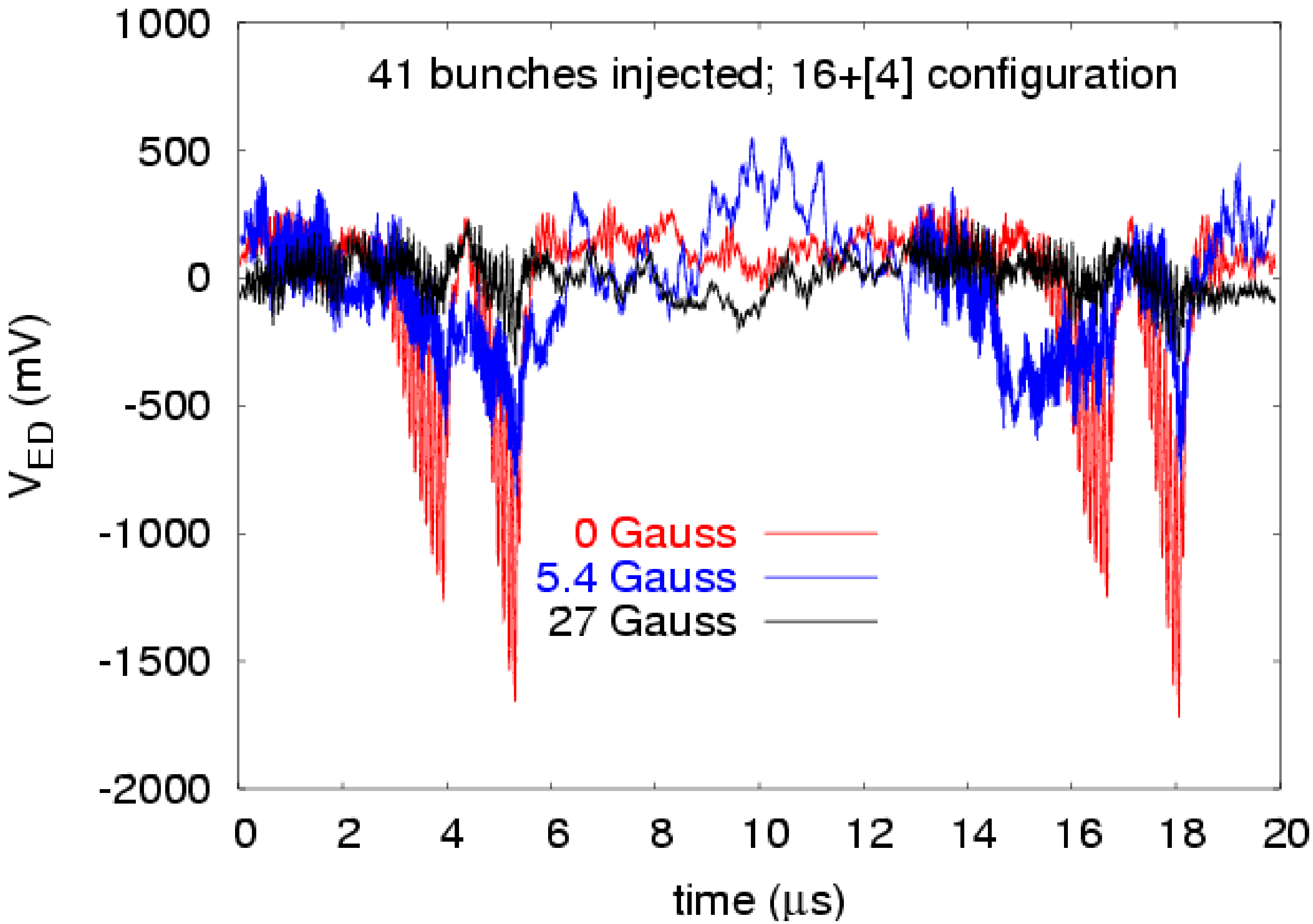
2.3. Use of the slow mode (1Hz sampling)

- Follow time evolution of ~minutes using MADC (Multi Analogic to Digital Converter).
- Allow correlations between P and I_{wall}, B and I_{wall}.
- Allow e- Energy spectra measurement.



- P rise due to electron induced desorption.
- Both P and e- current into the wall (I_{wall}) are ultimate functions of (bunched) beam.

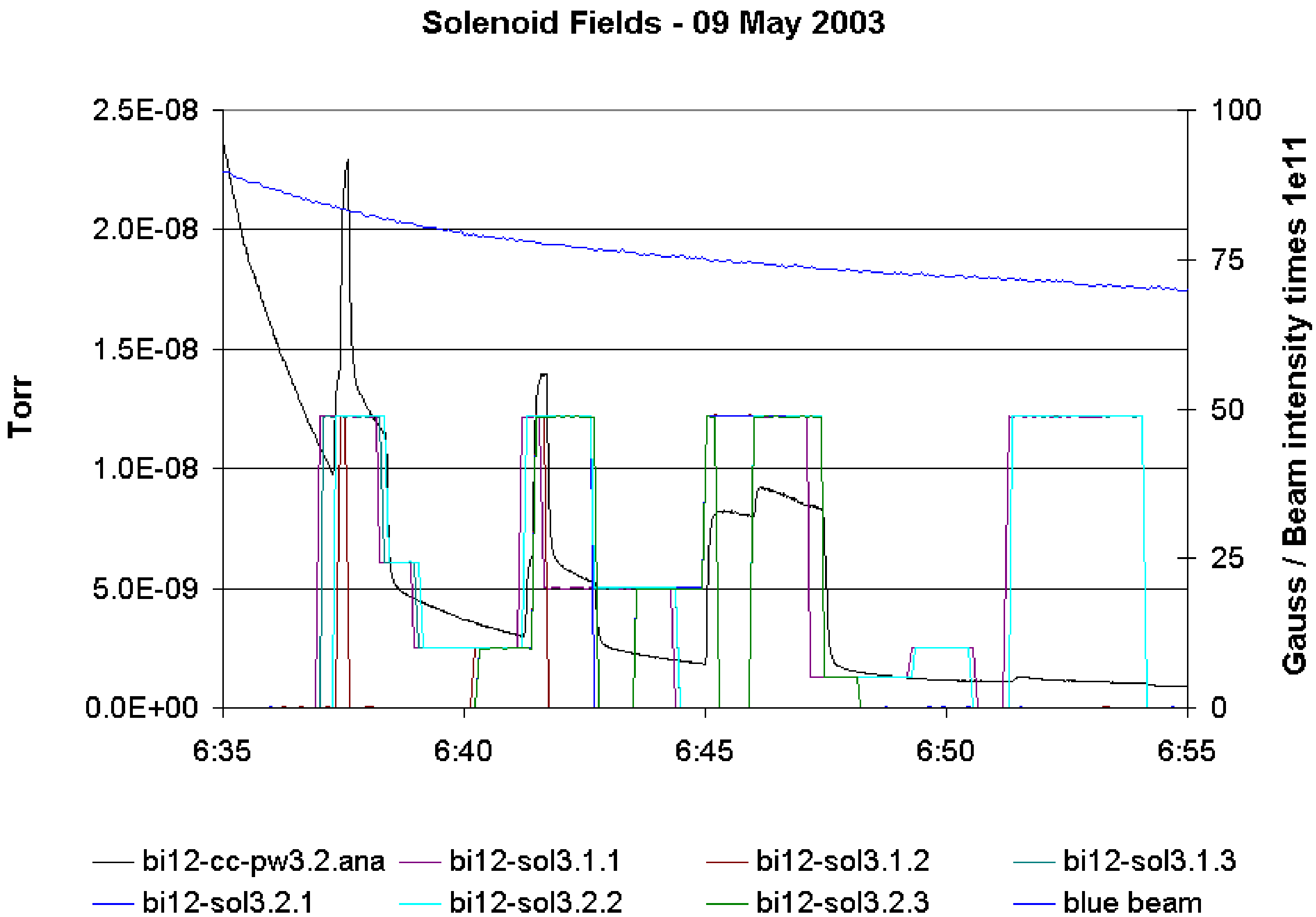
2.4. Solenoid field results (1)



?B=27Gauss sends signal below noise level => Solenoid field helps!
(*Fill #3530: N=10^{11} ppb*)

2.4. Solenoid field results (2)

?Fill #3667: For certain values of B, P increases!

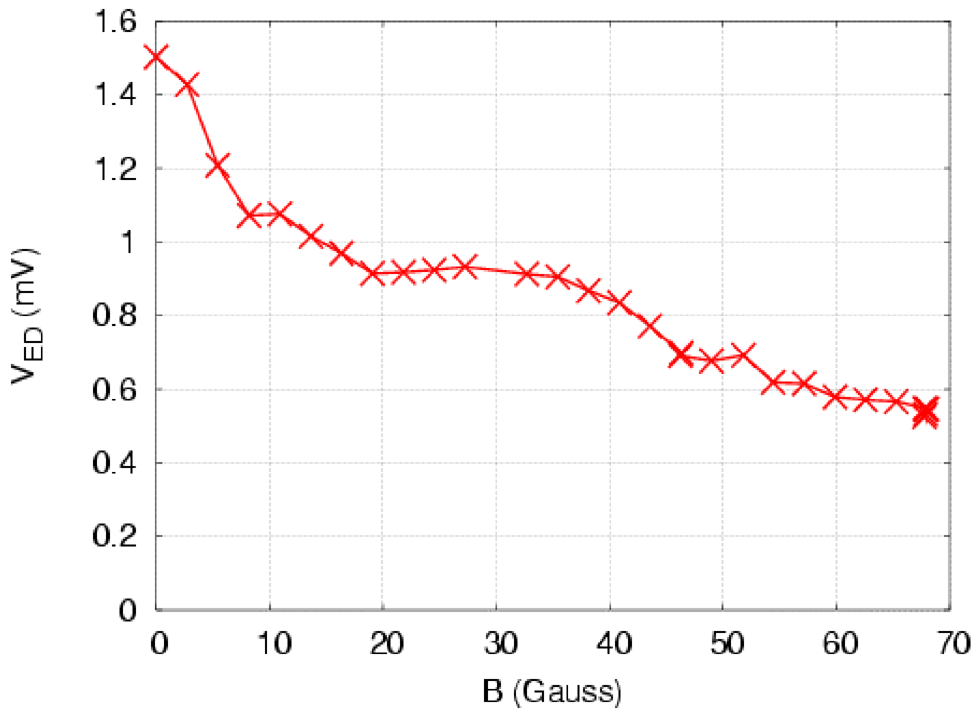


Courtesy of L. Smart

?Resonance effects? Cyclotron frequency does not match Bunch spacing.
?Importance of B allignement? *POSINST* results (P. He).

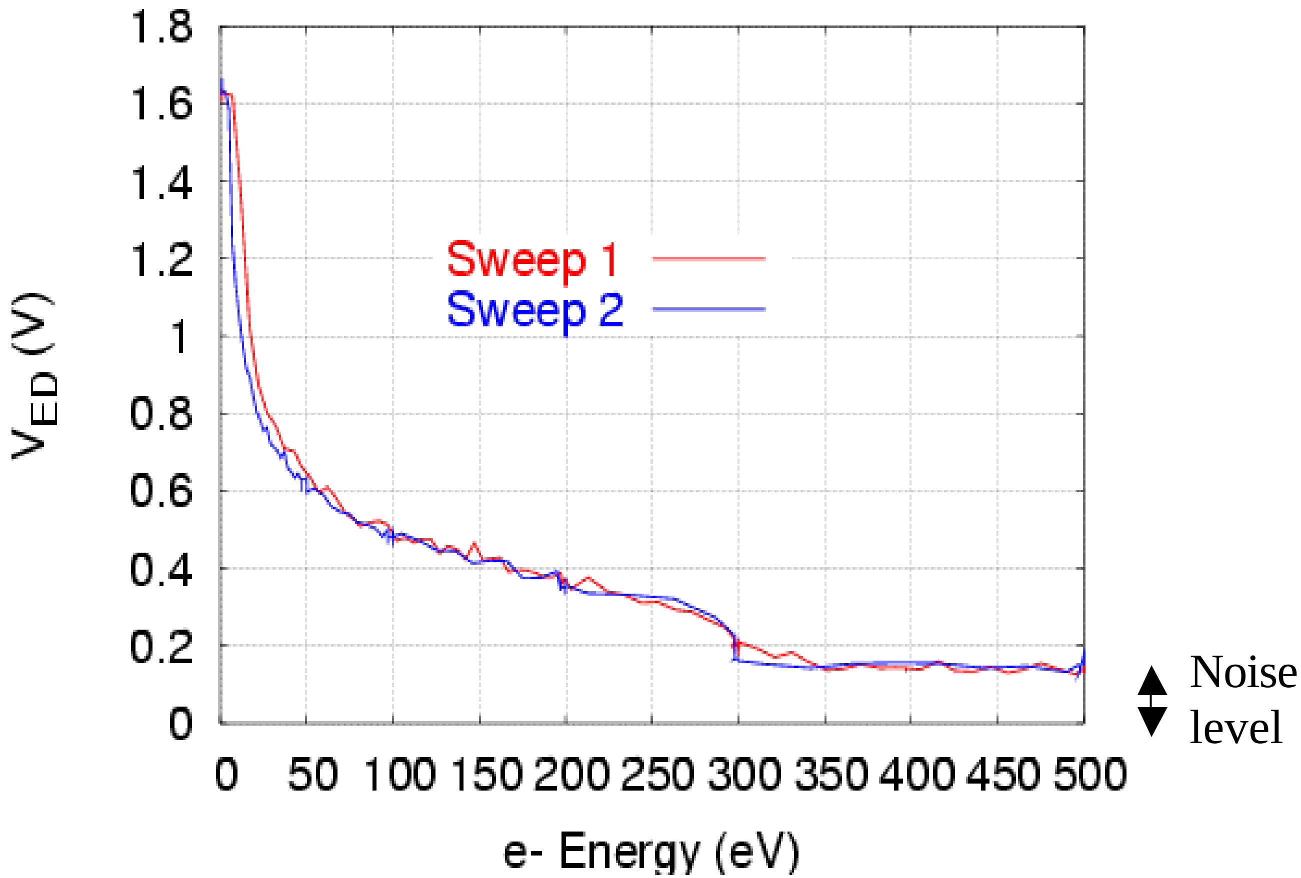
2.3. Solenoid field results (3)

B - Sweep during fill #3812. (*N=1.5 •10*^{10} *p-pb*).



?Even at the maximum value of B, V_{ED} is only reduced by a factor of ~3 (not enough to fully suppress the cloud).

2.5. e- Energy spectra measurement



?Large contribution of low Energy e- (<50eV) .

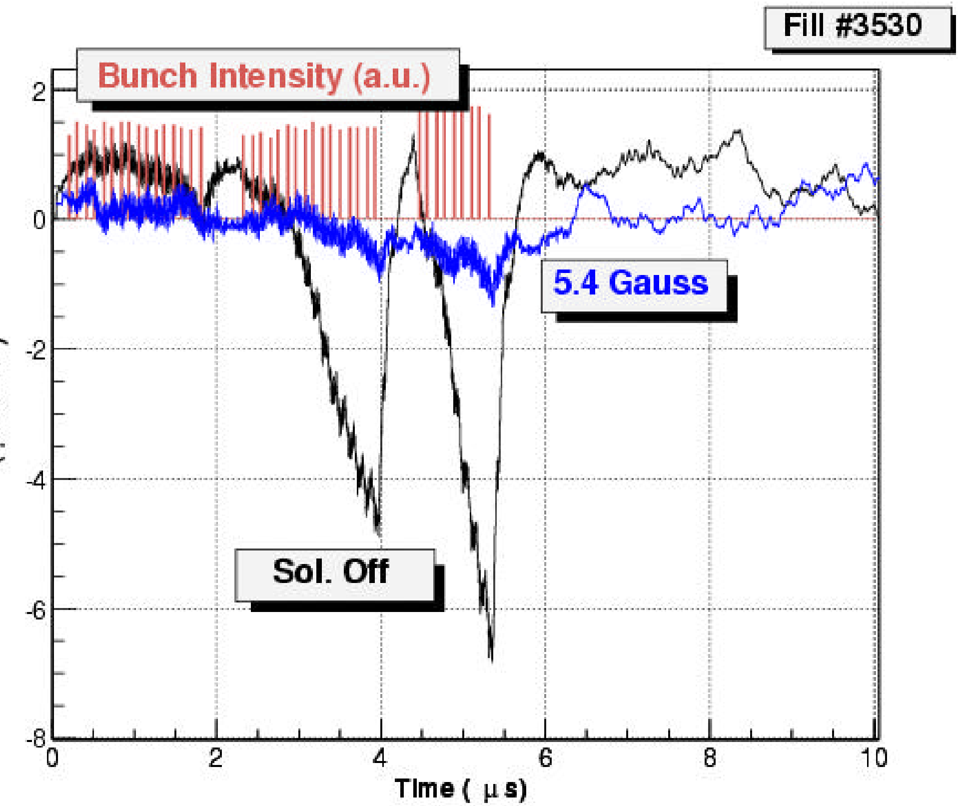
?e- Energy up to 300 eV (slow mode).

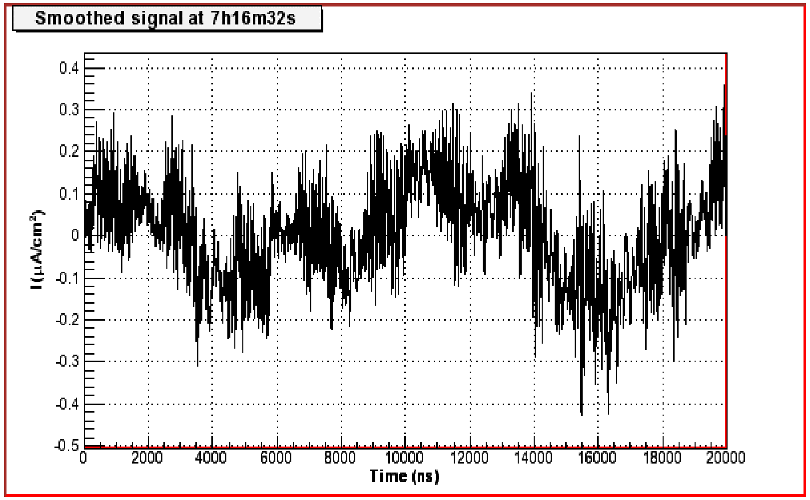
?Low Energy e-, low I_{wall} => unlike SPS (and predictions for LHC), scrubbing does not seem useful for RHIC.

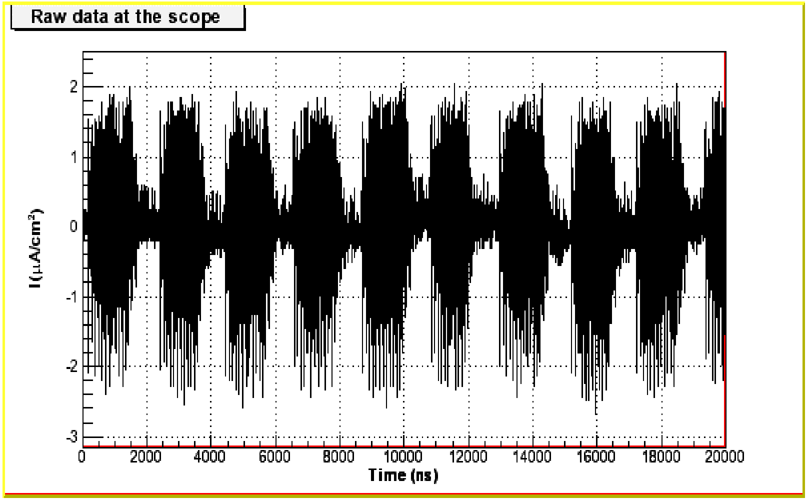
2.6. Missing bunches observations:

Goal: avoid triggering the effect by introducing some “missing bunches” along the bunch train.

Nomenclature: “filled” bchs + [“empty” bchs]







?16 bchs + 4 missing bchs does not avoid multipacting

?12 bchs + 8 missing bchs: the ED does not sho any signal (althogh small P rise was detected).

Summary of Observations:

?*EC was evidenced at RHIC during FY2003 for all species*

?*Solenoids did not provide satisfactory results, but cumbersome results, which are still being analysed.*

?*The e- Energy spectra shows large proportion of low Energy e- (< 50 eV) => scrubbing does not seem a good solution neither.*

?*The missing bunches method gives encouraging results. The 12+[8] configuration is a good candidate:*
->we still gain ~30% more Luminosity than with 56 bchs!

3. Electron Cloud simulations

3. Electron Cloud Simulations codes for RHIC

- Both ECLOUD (F.Zimmermann) and CSEC (M. Blaskiewicz) give similar and consistent results.
- CSEC can control the number of macroparticles -> can run faster.
- CSEC has been up-graded to use different bunch trains and bunch shapes, such as coming from the WCM signals->more real situation!

- After FY2003 run, the conclusion is that the use of missing bunches is the best candidate against EC (if other machine limitations do not coexist, such as transition type P rise, etc (see S.Y. Zhang, PAC'03)

4. EC mapping for RHIC

The EC evolution bunch-to-bunch can be
epresented by MAPS:

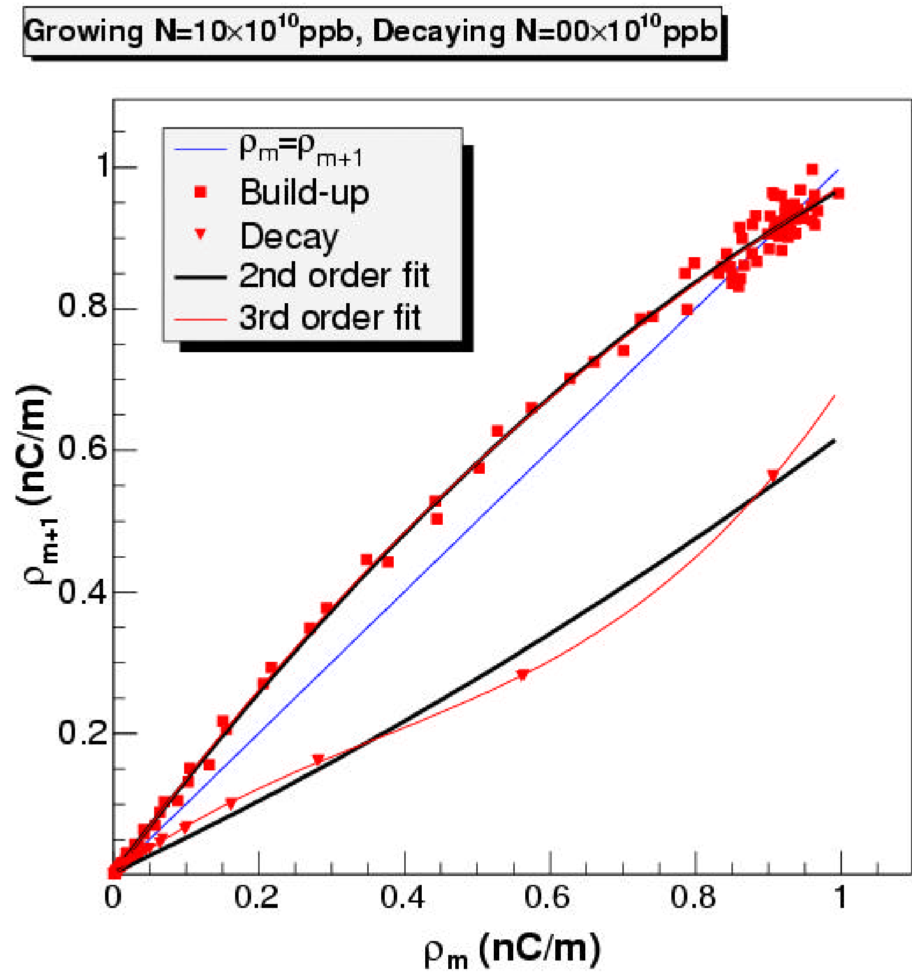
$$r_{m+1} = \mathbf{a_1}\ r_m + \mathbf{a_2}\ r^2_m$$

lso known as: $r_{m+1} = a \bullet r_m\ \mathbf{(1-}\ b \bullet r_m\mathbf{)}$

Only 2 parameters: for a given accelerator, all EC
ependence can be expressed only on N!

Fitting these 2 parameters for N after simulations
observations) can give us the evolution cloud
ensity after the pass of the mth bunch with only
ms!!

Very appropriate for the missing bunches studies.



Question:

For a given number of bunches n, in a train of m possible buckets, which is the best way to place the n bunches to minimize EC effect?

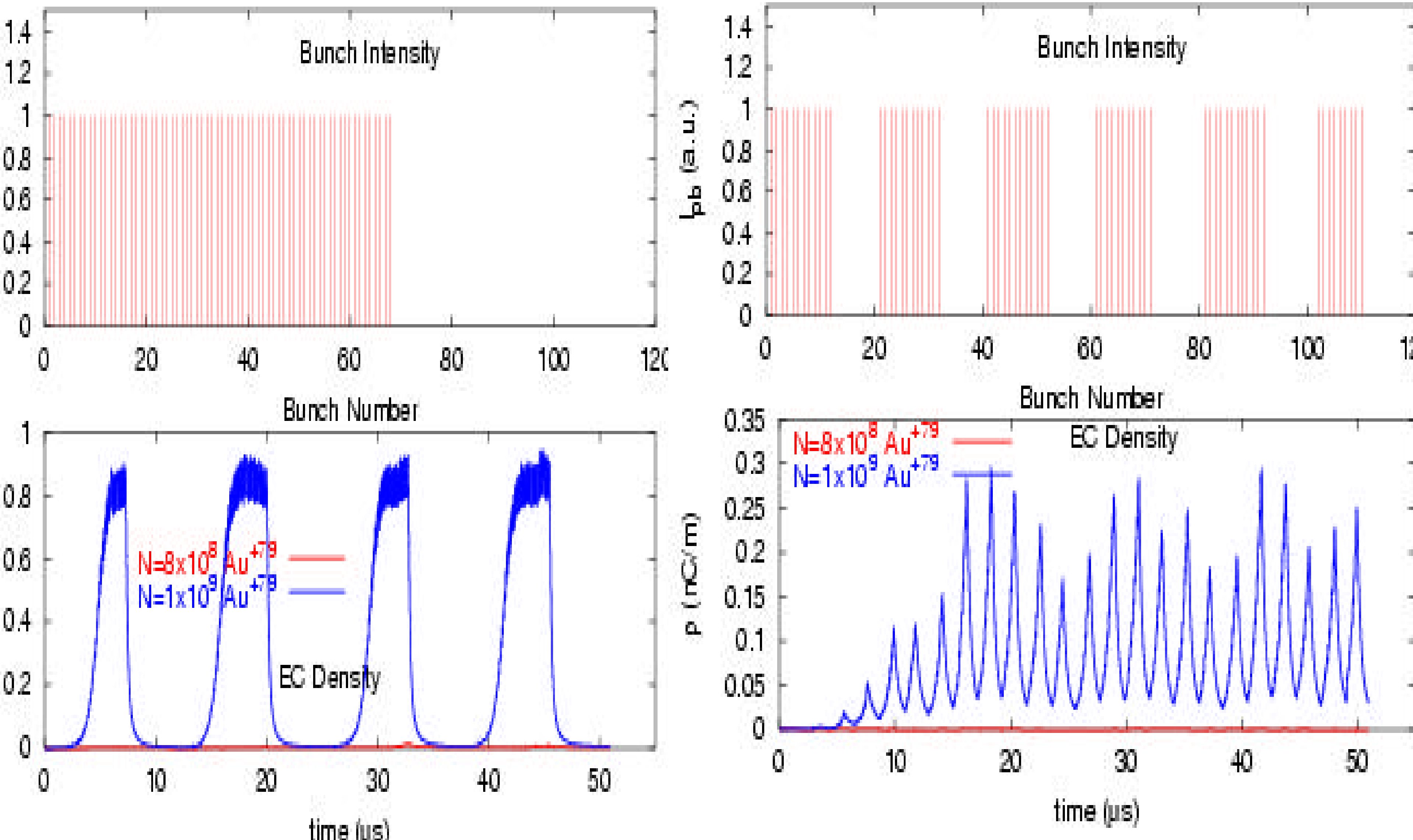
RHIC case: n=68 bunches in m=110 places

Possibilities=m!/(m-n)!n! ~10^30
(not all are relevant, hopefully...)

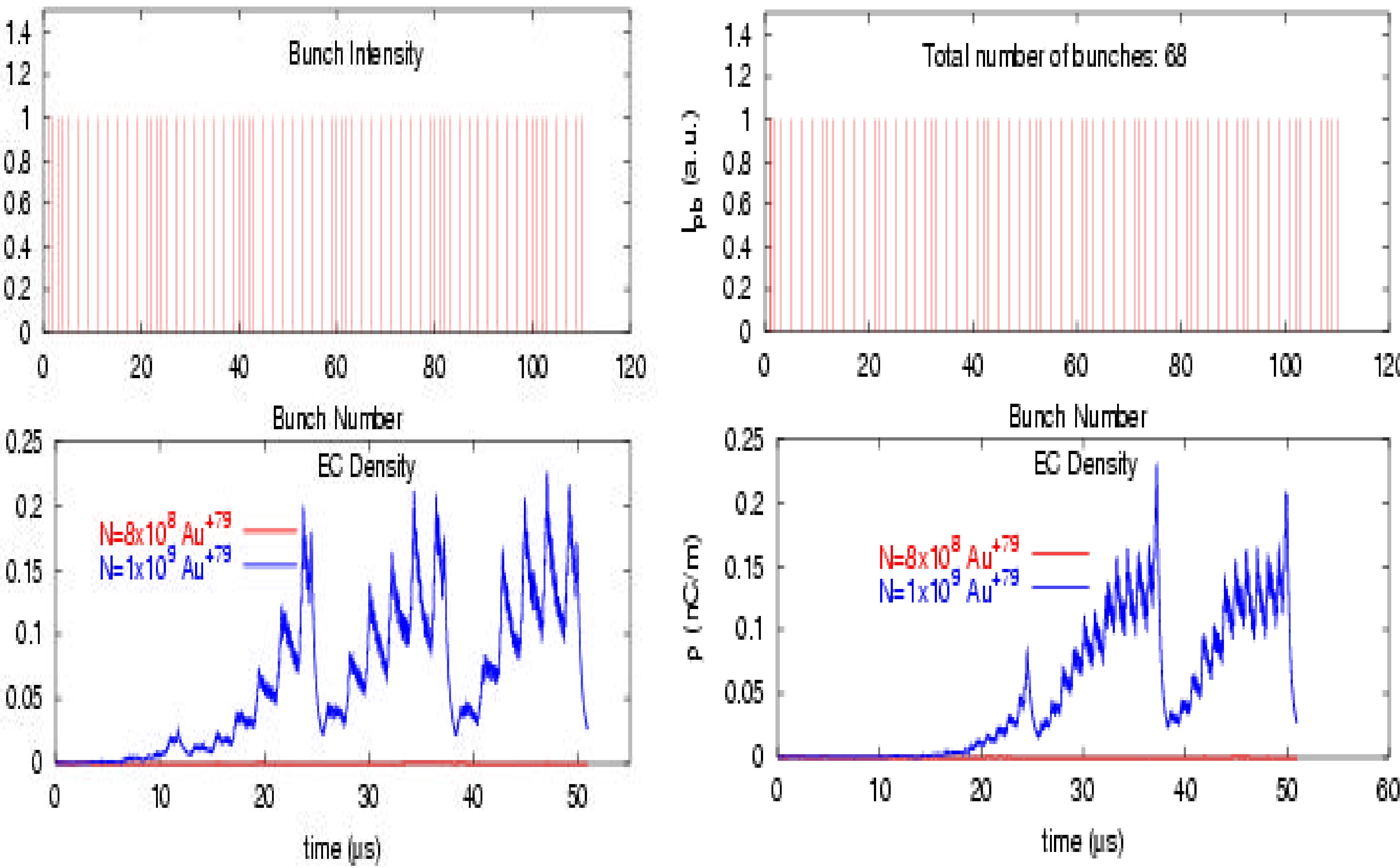
Using CSEC, or ECLOUD each case (meaning a n,m combination) takes between 1h -> days.

With MAPS, ~10 ms.

Example: some 68 bchs possibilities (1)



Some 68 bchs possibilities (2)

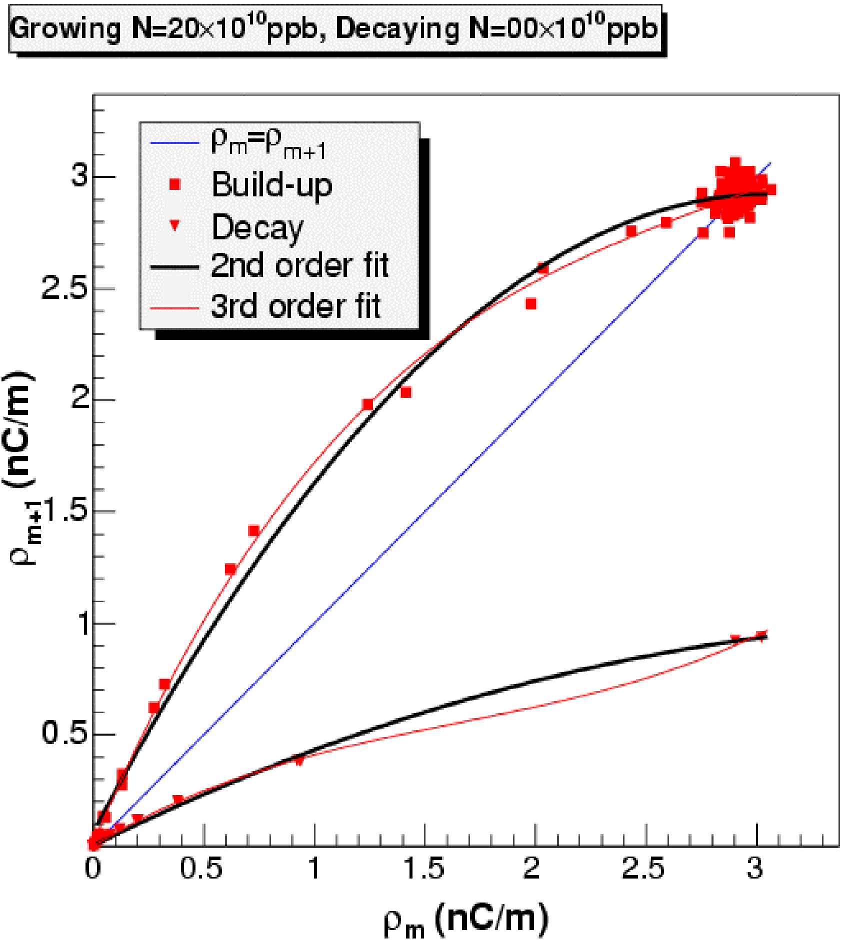


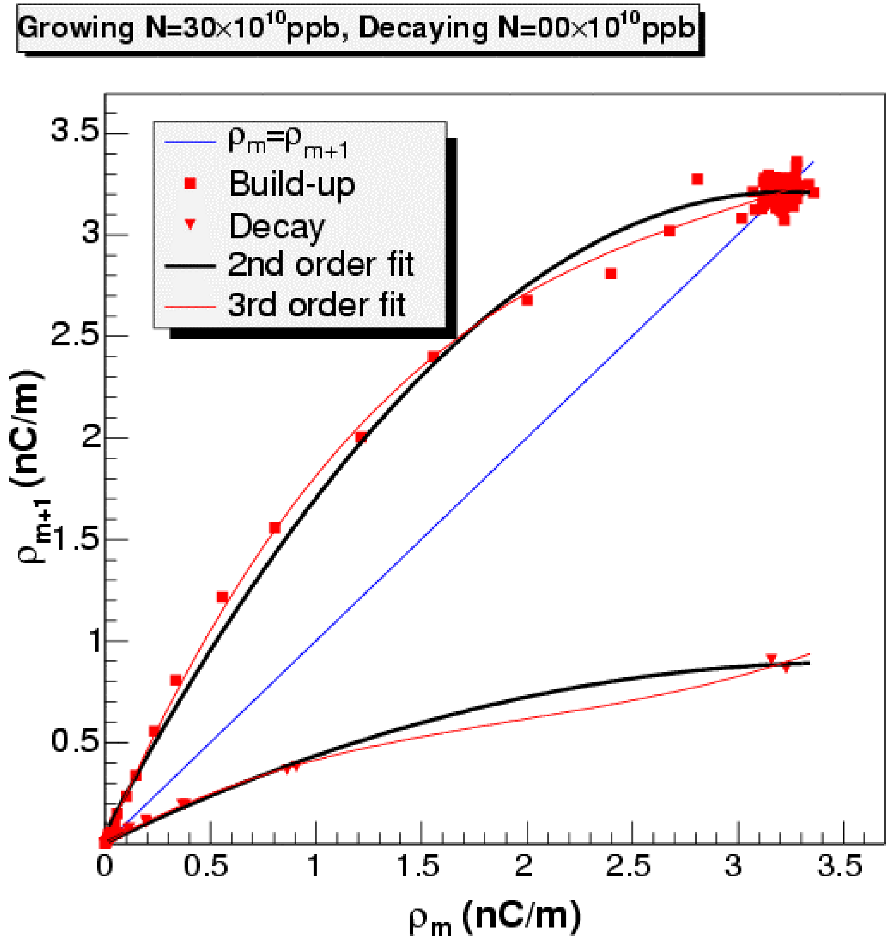
Timing using CSEC:

A 4 turns run, using:
N=1x10^9 Au pb
SEY=2.1
R0=0.6

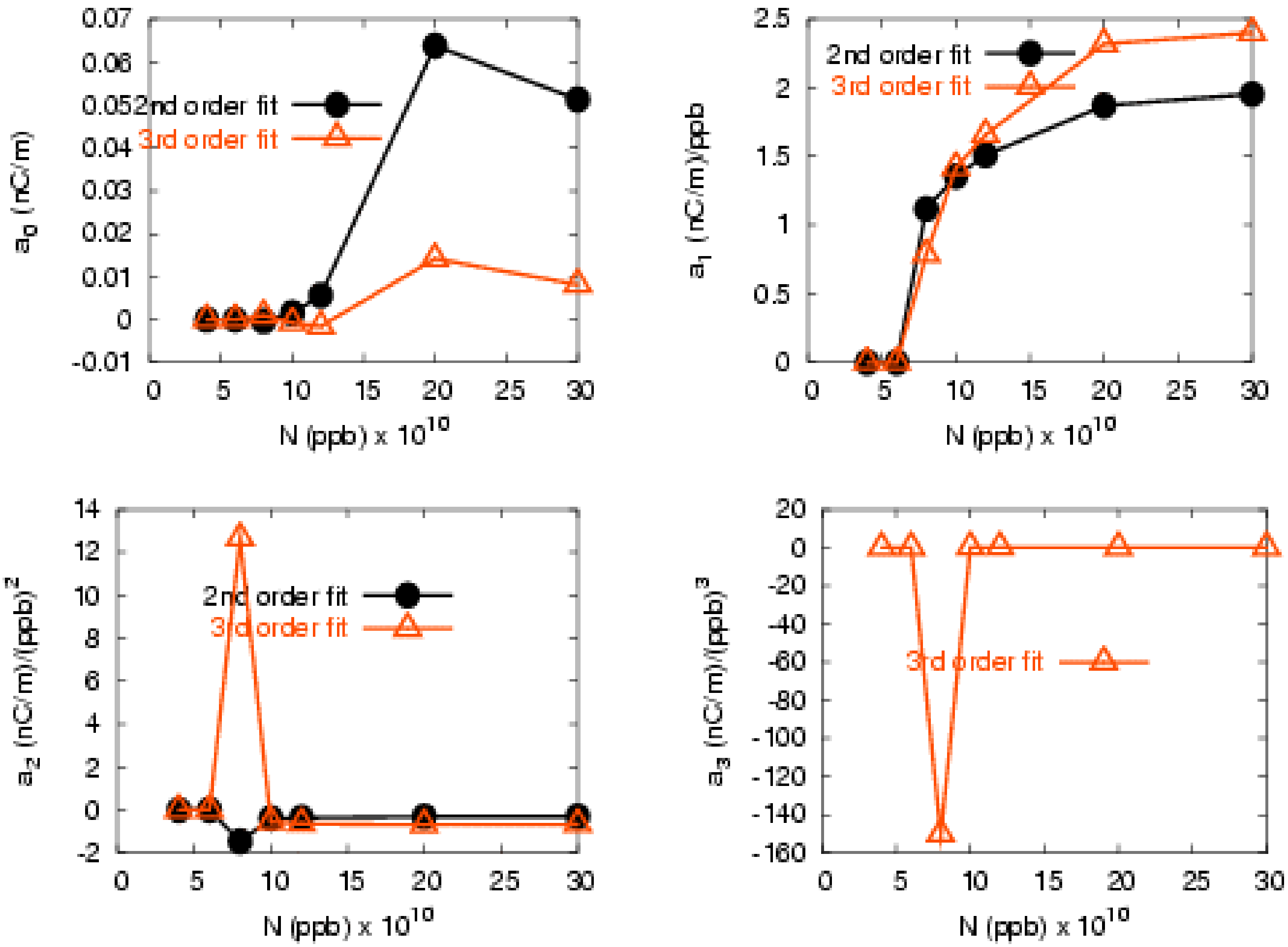
Fri Sep 12 17:22:43 EDT 2003
Fri Sep 12 19:46:38 EDT 2003

Since we ran CSEC for N=2, 4, 6… $\bullet 10^{10}$ p-pb, we could easily find the fitting parameters a_0, a_1.



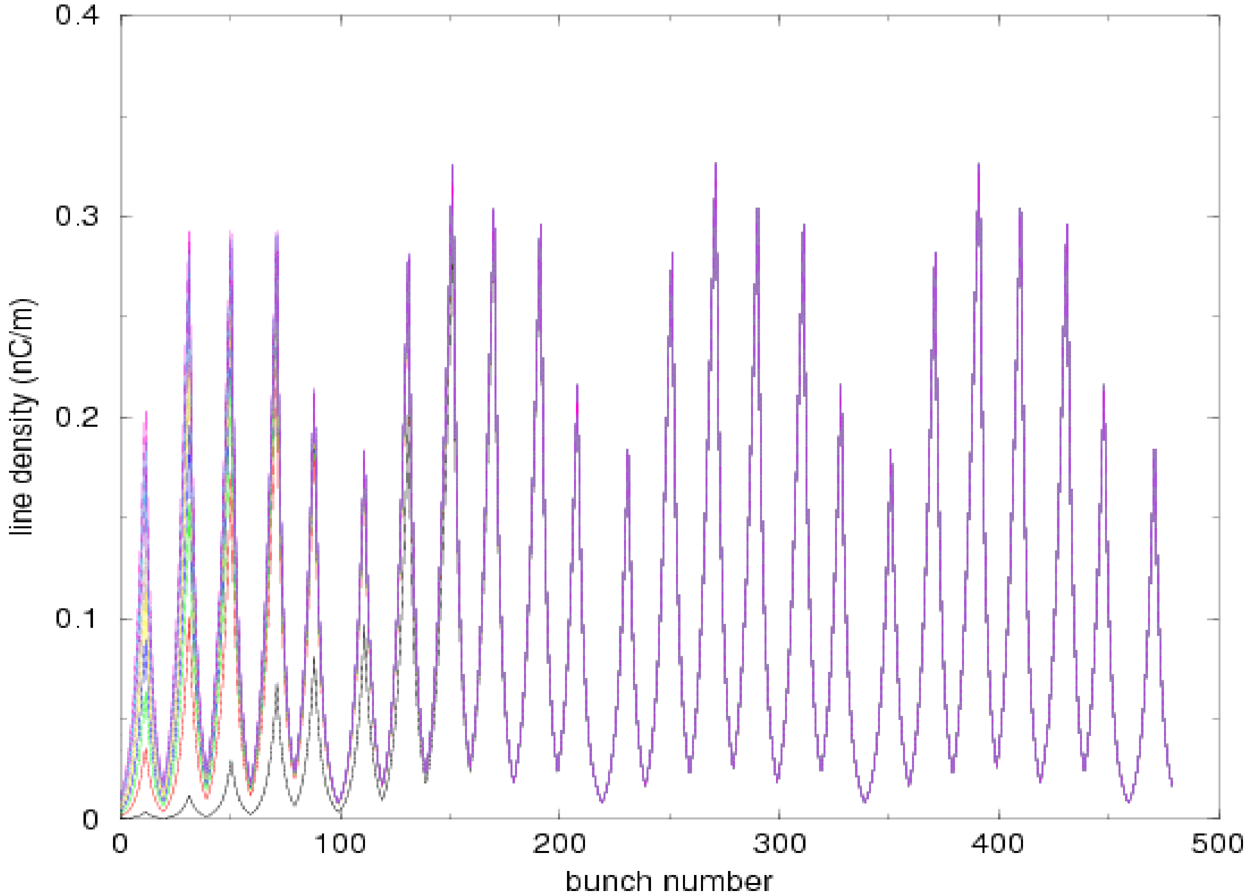


2nd and 3rd order fitting parameters:



Surface wall parameters: SEY=2.1, R0=0.5

Example assuming a 2nd order dependence. Bunch to bunch e- density evolution:



5. Conclusions:

- ?If we have to live with EC at RHIC, we better find a way to minimize the EC density-->optimize Luminosity
- ?EC mapping is a suitable solution to find optimum bunch train configurations--> It runs 10^4 times faster!!
- ?In general, one can always “map” the EC for a given accelerator and find the optimum bunch train configuration.

Question to LHC:

- ?Is this solution suitable for LHC beam-type?
- ?Is it plausible to permute m (<72) filled buckets within 72 bunches/batch?